Provincial Report

Biology 30

Grade 12 Diploma Examination

April 1984

Student Evaluation

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TABLE OF CONTENTS

	PAGE
PREFACE	iii
ACKNOWLEDGMENTS	iv
CHAPTER 1: GRADE 12 DIPLOMA EXAMINATIONS PROGRAM	1
Introduction	1
General High School Diploma	1
Advanced High School Diploma	1
Awarding of Course Credits	1
Transitional Provisions	2
Award of Excellence	2
CHAPTER 2: DESCRIPTION OF THE EXAMINATION	3
Examination Development	3
Examination Description	4
Explanation of Blueprint Thought Levels	6
Description of Subject Matter Areas and Sample Multiple-Choice Questions	7
1. Physical Properties of Cells	7
2. Nutrition	7
3. Circulation	9
4. Gas Exchange	9
5. Cellular Respiration	10
6. Excretion	11
7. Metabolic Controls	11
8. Human Reproduction	12
9. Scientific Process Skills	13
Written-Response Questions	14
CHAPTER 3: RESULTS	19
Validity and Reliability	19
Provincial Averages	19
Comparison of Multiple-Choice and Written-Response Questions	21
Standard-Setting	23
Transformation of Examination Marks	23
Relationship Between Examination Mark and School Mark	24
Results for Individual Questions	24
Multiple-Choice Questions	24
Written-Response Questions	26

LIST OF TABLES

TABLE		PAGE
1	January 1984 Biology 30 Diploma Examination Blueprint	5
2	Provincial Averages for Subtests	20
3	Transformation of Examination Marks	23
4	Summary Statistics for School Mark, Examination Mark, and Final Mark	24
5	Percentages of Students Receiving A's, B's, C's, and F's	24
6	Results for Individual Multiple-Choice Questions	25
7	Distribution of Marks for Written-Response Questions	26
8	Average Marks Awarded for Written-Response Questions	26

PREFACE

This report presents the provincial results of the Biology 30 Diploma Examination administered on January 27, 1984. During this first administration, the Biology 30 Diploma Examination was written by 5558 students. This report is intended to provide more information about the examination development process, the examination itself, and the examination results.

ACKNOWLEDGMENTS

This first administration of the Biology 30 Diploma Examination was successful due to the concerted effort of all involved. Success would have been impossible without substantial contributions from many people, particularly the administrators, teachers, and students, who extended their full co-operation.

The technical expertise and advice received from the Examination Review Committee regarding design, development, and reporting have been particularly valuable in the implementation of this diploma examination. This Committee has representation from:

The Alberta Teachers' Association
The Conference of Alberta School Superintendents
The Universities Co-ordinating Council
The Public Colleges of Alberta
Alberta Education

The contribution of this group is gratefully acknowledged.

Lloyd E. Symyrozum
Director
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CHAPTER 1

Grade 12 Diploma Examinations Program

Introduction

All Grade 12 students in Alberta are now required to write at least ONE diploma examination to receive a high school diploma. Mature students may receive credits for a Grade 12 course by writing the appropriate diploma examination. They are not required to be registered in the course. The Grade 12 Diploma Examinations Program, which is an integral part of the high school diploma requirements, is intended to develop and maintain excellence in educational standards through certification of academic achievement.

The Diploma Examinations Program consists of course-specific examinations that are based on the prescribed *Program of Studies for Senior High Schools* for the following Grade 12 courses: English 30, English 33, Social Studies 30, Mathematics 30, Biology 30, Chemistry 30, and Physics 30.

Alberta Education issues two distinct high school diplomas: the General High School Diploma and the Advanced High School Diploma.

General High School Diploma

To earn a General High School Diploma, a student must obtain course credit in either English 30 or English 33, and obtain 100 credits distributed over courses as specified in the *Junior-Senior High School Handbook*. Some students who are working toward the general diploma may wish to obtain credits in other diploma examination courses (i.e., Social Studies 30, Mathematics 30, Biology 30, Chemistry 30, and Physics 30). To obtain credits in these courses, a student must also write the appropriate diploma examination regardless of the type of diploma he wishes to receive.

Advanced High School Diploma

The Advanced High School Diploma represents achievement in an academic program that includes language arts (English), social studies, mathematics, and science. To earn an Advanced High School Diploma, a student must satisfy the current course and credit requirements for a General High School Diploma, and obtain course credits in English 30, Social Studies 30, Mathematics 30, and ONE of Biology 30, Chemistry 30, or Physics 30.

Awarding of Course Credits

Grade 10 and Grade 11 Courses. To obtain credits in Grade 10 (10-level) and Grade 11 (20-level) courses, a student must earn a final mark of 40% or better. A student who has achieved a mark of 50% or higher in a given course is eligible to take the next or higher-rank high school course in that sequence.

Grade 12 Courses. To obtain credit in a Grade 12 (30-level) course, a student must earn a final mark of 50% or better. To obtain credit in a Grade 12 diploma examination course, a student must write the appropriate diploma examination and attain a final blended mark of 50% or better. The final blended mark is made up of 50% of the mark awarded by the school and 50% of the diploma examination mark. For example, a student taking Chemistry 30 might have a mark of 45% from his school and a mark of 57% on the diploma examination. This student would earn credits for Chemistry 30 because his final mark would be 51%, which is the average of the school and examination marks. For mature students who do not have a school mark or who have a school mark lower than the examination mark, the examination mark is the final mark.

Transitional Provisions

During the 1983-84 school year, Alberta Education will recognize all course credits earned prior to September 1, 1983, for the purpose of awarding the General High School Diploma.

Students who have completed partial requirements for the Advanced High School Diploma prior to September 1, 1983, and who are enrolled in Grade 12 courses during the 1983-84 school year, may apply any of the previously completed required diploma examination subjects toward a diploma, provided they have earned a final course mark of 50% or better in each subject.

Award of Excellence

When candidates for an Advanced High School Diploma obtain a final average of 80% or higher on the four required diploma examination courses with not less than 65% in any one of these four required courses, they receive an Award of Excellence. This Award of Excellence is noted on the student's Advanced High School Diploma. When a student writes two or three of the diploma examinations in Biology 30, Chemistry 30, and Physics 30, the highest of these final course marks is used for diploma purposes and in the calculation of the average for the Award of Excellence.

CHAPTER 2

Description of the Examination

This chapter outlines the procedures that were followed during test development and describes the structure and content of the examination. Sample questions from the January 1984 examination are included.

Examination Development

There were three stages in the development of the January 1984 Biology 30 Diploma Examination: preparation of curriculum specifications, development of questions, and selection of questions for the final copy.

1. Curriculum Specifications

   The Curriculum Branch of Alberta Education prepared curriculum specifications based on the topical outline of the Biology 30 core described in the *Program of Studies for Senior High Schools*. In these specifications, weightings were assigned to each major content area and to specific topics outlined in the *Program of Studies*. These weightings were based on the emphasis that each topic was to receive in the Biology 30 program. The curriculum specifications were distributed to all school jurisdictions in the province.

   Topic statements upon which specific questions were based, along with the sample questions for each topic, are given in this chapter.

2. Development of Questions

   Committees composed of teachers and Student Evaluation Branch personnel constructed questions to reflect the content statements listed in the curriculum specifications. The questions were field-tested, and revisions were made on the basis of teacher recommendations and the field-test results.

3. Final Copy

   A test development specialist, assisted by groups of classroom teachers, built the examination from suitable questions. These committees selected questions from various content areas, so that each area received the emphasis recommended in the curriculum specifications. An Examination Review Committee checked the proposed examination for content validity, accuracy, and technical merit, and further changes were made in accordance with their recommendations.

Examination Description

On the Biology 30 Diploma Examination, each content area received the following emphasis:

Content Area	Emphasis in % of the Total Examination Mark
Physical Properties of Cells	15
Nutrition	19
Circulation	13
Gas Exchange	7
Cellular Respiration	8
Excretion	7
Metabolic Controls	24
Human Reproduction	7

To the extent that paper-and-pencil testing permitted, the Biology 30 Diploma Examination assessed the application of the scientific process skills of predicting, hypothesizing, controlling variables, interpreting data, inferring, and processing data. The questions that are readily identified with specific process skills are listed below.

Process Skill	Multiple-Choice Question	Written-Response Question
Interpreting Data	6,10,16,18,19,27,34,48,52,69,70	3,5
Inferring	43,69,79	3,4
Predicting	7,17,18,35,57,75	1,5,6,8
Processing Data	10,17,18,27,43,70,71	4,8
Hypothesizing	36,57	1
Controlling Variables	31,36,57,73	1,4,8

Understandably, the experience gained by direct, hands-on activities are difficult to measure outside a laboratory situation and should therefore be reflected in student performance as evaluated by the teacher.

Subject matter in the attitudinal and psychomotor components of the program was also excluded from the diploma examination.

The time allotted for the Biology 30 Diploma Examination was two and one-half hours. The examination consisted of both multiple-choice questions (worth 80% of the total examination mark) and written-response questions (worth 20% of the total examination mark). There were 80 multiple-choice questions worth one mark each and eight written-response questions worth a total of 20 marks.

The classification of examination questions according to content area and taxonomic level is presented in Table 1.

Table 1

January 1984 Biology 30 Diploma Examination Blueprint

Subject Matter Area	Question by Taxonomic Level			Examination Emphasis
	Knowledge	Application and Understanding	Higher Mental Activities	
Physical Properties of Cells	2,3,4,8,11	1,5,6,7,9,12 [1]	10	15%
Nutrition	22,23 [2]	13,14,15,16,18, 19,20,21,24	17,27,28 [5]	19%
Circulation	26,29,30,32, 33,36	25,31,34 [4]	35	13%
Gas Exchange	37,38,42	39,40,41	43	7%
Cellular Respiration	45,49,51	44,46,47,48,50	0	8%
Excretion	55	52,53,54,56	0 [8]	7%
Metabolic Controls	58,59,62,64, 66,72	60,61,63,65, 67,68,73 [3,6,7]	57,69,70,71	24%
Human Reproduction	76,80	74,75,77,78	79	7%
Examination Emphasis	31%	54%	15%	100%

Note: Numbers in brackets [ ] indicate the written-response questions.

Explanation of Blueprint Thought Levels

1. Knowledge

Knowledge is defined as including those behaviors and test situations that emphasize the remembering, either by recognition or recall, of ideas, material, or phenomena. Incorporated at this level is knowledge of terminology, specific facts (dates, events, persons, etc.), conventions, classifications and categories, methods of inquiry, principles and generalizations, and theories and structures.

2. Application and Understanding

Application requires the student to apply an appropriate abstraction (theory, principle, idea, method) to a new situation.

Understanding refers to responses that represent a comprehension of the literal message contained in a communication. This means that the student is able to translate, interpret, or extrapolate. Translation refers to the ability to put a communication into another language. Interpretation involves the reordering of ideas (inferences, generalizations, or summaries). Extrapolation includes estimating or predicting based on an understanding of trends or tendencies.

3. Higher Mental Activities

Included in higher mental activities are the processes of analysis, synthesis, and evaluation. Analysis involves the ability to recognize unstated assumptions, to distinguish facts from hypotheses, to distinguish a conclusion from statements that support it, to recognize which facts or assumptions are essential to a main thesis or to the argument in support of that thesis, to distinguish cause-effect relationships from other sequential relationships, and to recognize the point of view of a writer.

Synthesis involves the production of a unique communication, the ability to propose ways of testing a hypothesis, the ability to design an experiment, the ability to formulate and modify a hypothesis, and the ability to make generalizations.

Evaluation is defined as the making of judgments about the value of ideas, solutions, and methods. It involves the use of criteria as well as standards for appraising the extent to which details are accurate, effective, economical, or satisfying. Evaluation involves the ability to apply given criteria to judgments of work done, to indicate logical fallacies in arguments, and to compare major theories and generalizations.

The taxonomic classification of examination questions may depend on the manner in which the content has been covered in the classroom. A question that is an application question for one class may be a knowledge question for another class.

Questions requiring knowledge and skill in the processes of science were included throughout the examination and are not associated with any specific topic or thought level.

Description of Subject Matter Areas and Sample Multiple-Choice Questions

The topics that were tested within each content area are listed and sample questions from the test are provided. The correct response for each question is identified by an asterisk and the percentage of students selecting each response is given.

1. Physical Properties of Cells

Cellular processes are not only fundamental to all life forms, but are also considered to be an essential unit in Biology 30. If the students cannot comprehend and apply the concepts learned in this unit, then they will not be able to transfer the necessary knowledge to subsequent units. The specific topic statements covered by the examination were:

- cells exhibit complex structure and function
- living organisms carry out chemical activities
- substances necessary for life are transported by physical and chemical processes

The following example requires students to recall knowledge related to the physical properties of cells.

Question 11:

Enzymes act in chemical reactions to

Student Responses

5.5%	A.	prevent energy loss
68.9%	*B.	lower the amount of energy required to initiate the reaction
22.0%	C.	increase the energy of the reactants
3.6%	D.	prevent the diffusion of reactants away from each other
0.1%		no response

2. Nutrition

The 1984 diploma examination reflected the transitional nature of the curriculum in that both autotrophic and heterotrophic nutrition from topics in the 1975 curriculum were covered.

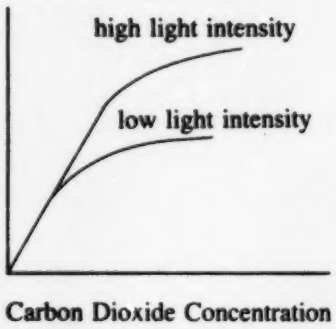
The questions on autotropism were selected from the autotrophic nutrition subtopic.

The following example requires students to interpret data from a graph and make predictions regarding this data.

Question 17:

Use the following information to answer question 17.

Effect of Light Intensity and Carbon Dioxide Concentration on the Rate of Photosynthesis



A correct conclusion one could draw from the graph is that

Student Responses

5.6%	A.	high light intensity is necessary for photosynthesis to occur
30.1%	*B.	assimilation of carbon dioxide varies with different light intensities
28.5%	C.	the carbon dioxide concentration required is directly proportional to the rate of photosynthesis
35.7%	D.	as the rate of photosynthesis increases, the light intensity must increase
0.1%		no response

The questions on heterotropism focused primarily on human nutrition. The specific topic statements covered by the examination were:

- digestion includes the physical and chemical breakdown of ingested macromolecules, preparing them for absorption
- unusable substances are stored, then removed from the body
- environmental toxins may be retained by body tissue

The following example requires students to apply principles related to nutrition.

Question 24:

In the small intestine, the substance MOST likely to be absorbed by active transport is

Student Responses

27.9%	A.	protein
12.0%	B.	salt
34.2%	*C.	glucose
25.8%	D.	water
0.1%		no response

3. Circulation

Due to the important functions of body fluids, the diploma examination contained a representative number of questions on circulation. The questions were all directly related to the human circulatory system, including the components and functions of the system. The specific topic statements covered by the examination were:

- the heart and blood vessels are structured to facilitate circulation
- blood is the primary circulating body fluid
- lymph is a secondary circulating body fluid
- homeostatic controls maintain cardiac output and blood pressure

The following example requires students to demonstrate comprehension of the various components of the circulatory system.

Question 30:

The portion of the circulatory system with the largest TOTAL surface area is the

Student Responses

6.2%	A.	small veins
6.7%	B.	arterioles
81.0%	*C.	capillaries
6.0%	D.	large arteries
0.0%		no response

4. Gas Exchange

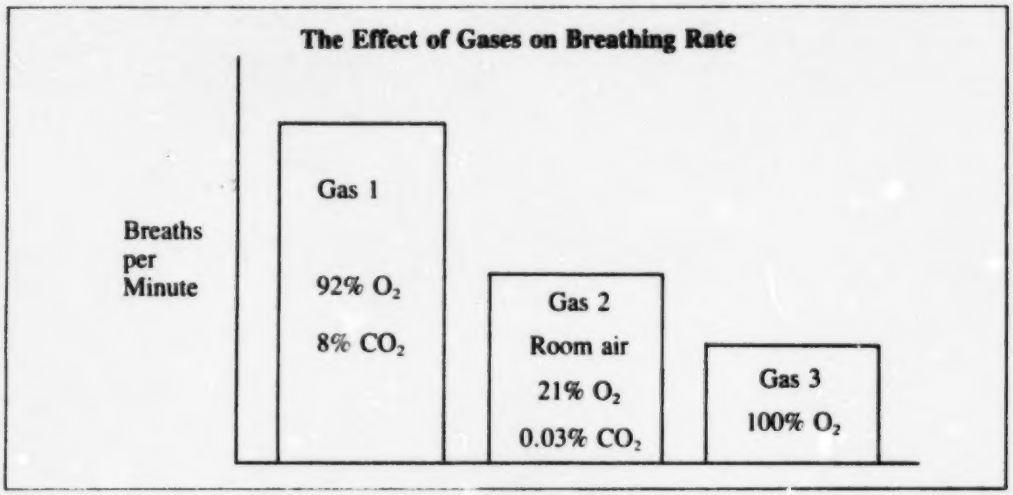
Questions on gas exchange are related to the mechanics of breathing, the exchange and transport of gases in humans, and the homeostatic mechanisms required to maintain the systems involved. The specific topic statements covered by the examination were:

- mechanics of breathing include inhalation and exhalation
- gas exchange occurs between blood and body tissues
- blood is necessary for gas transport
- breathing rate is controlled by respiratory centres in the medulla
- blood oxygen levels affect the rate of red blood cell production

The following example requires students to interpret the data based on the principles involving gas exchange and breathing rate. The question attempts to evaluate the students' comprehension of these principles.

Question 43:

Use the following information to answer question 43.



The breathing rate is regulated by the

Student Responses

17.9%	A.	concentration of oxygen
76.1%	*B.	concentration of carbon dioxide
1.2%	C.	temperature of the gas
4.7%	D.	volume of the gas
0.0%		no response

5. Cellular Respiration

The human organism must be able to supply its varying need for energy. Students must understand the three basic concepts of cellular aerobic and anaerobic respiration. They should be able to demonstrate their comprehension by applying the various concepts to the many energy-requiring human processes. The specific topic statements covered by the examination were:

- cellular respiration involves three basic concepts
- anaerobic respiration in muscle cells
- aerobic respiration
- ATP released during cellular respiration is utilized for several metabolic processes including anabolism, movement and muscle contraction, heat production, and active transport

In the following example of a question from the topic dealing with cellular respiration, students are required to demonstrate comprehension of anaerobic respiration in (human) muscle cells.

Question 44:

The breathing rate of a runner who finishes a 3000 m race remains quite high for a period of time. This rapid rate is because of

Student Responses

74.8%	*A.	the oxygen debt
8.3%	B.	hyperventilation
10.2%	C.	carbon dioxide deprivation
6.7%	D.	the accumulation of pyruvic acid
0.0%		no response

6. Excretion

The study of the excretory system was limited to that found in humans. The anatomy of the entire system was studied in relation to the functions performed by the kidneys. Students were taught to view the excretory system as a homeostatic device. The specific topic statements covered by the examination were:

- the excretory system removes waste products from the blood
- body fluid balance is maintained by hormones and ions

The following example requires students to apply the principles learned concerning the kidneys as a homeostatic mechanism.

Question 56:

A build-up of water in the blood will result in

Student Responses

46.4%	*A.	decreased production of anti-diuretic hormone by the body
14.1%	B.	decreased urine formation by the kidneys
27.6%	C.	increased activity of osmoreceptors
11.8%	D.	decreased blood pressure maintaining homeostasis
0.1%		no response

7. Metabolic Controls

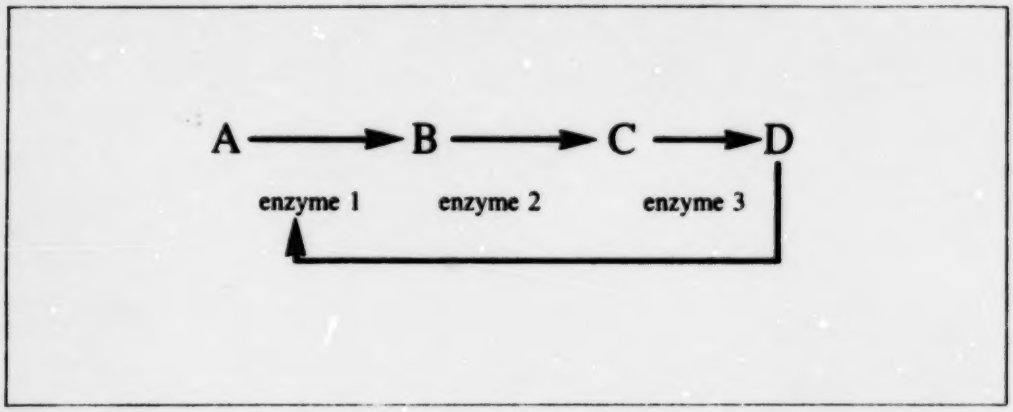
Regulation of the internal environment requires co-ordination between nervous and hormonal systems. Using the human body system as an example, students should be able to comprehend the relationship between the two systems and to apply the principles involved. The specific topic statements covered by the examination were:

- nervous control involves reception, transmission, interpretation, and response
- endocrine secretions regulate and maintain bodily functions

The following example requires students to interpret the data presented. By applying the underlying principles, students should be able to predict the outcome of a hypothetical situation. The question involves interpretation, comprehension, application, and prediction skills.

Question 57:

Use the following information to answer question 57.



If the level of D in the cell is controlled by feedback inhibition (negative feedback), the effect of high concentrations of D in the cell would be to

Student Responses

27.5%	A.	stimulate the conversion of substance A to B
54.5%	*B.	inhibit the conversion of substance A to B
8.6%	C.	stimulate the conversion of substance B to C
9.4%	D.	inhibit the conversion of substance B to C
0.0%		no response

8. Human Reproduction

By understanding the development and functioning of the human male and female reproductive systems, students should be able to comprehend the fertilization process. The specific topic statements covered by the examination were:

- reproductive systems
- the development and functioning of the reproductive system is under the control of hormones
- fertilization

The following example requires students to analyse a hypothetical situation and, based on the menstrual cycle principle, predict the outcome.

Question 78:

An extremely high concentration of progesterone is administered to a woman on the 17th day of a 28-day menstrual cycle. The high concentration of progesterone would very quickly promote

Student Responses

25.7%	A.	ovulation on the 18th day of the menstrual cycle
41.9%	*B.	deterioration of the corpus luteum and then menstruation
23.5%	C.	rapid follicle development (in the ovaries)
8.9%	D.	pregnancy
0.1%		no response

9. Scientific Process Skills

The process skills covered by the examination were:

Interpreting Data - the process of recognizing patterns in data, identifying relationships between variables, and forming generalizations.

Inferring - the process of arriving at a tentative explanation or conclusion based on direct or indirect observations.

Predicting - the process of formulating a specific forecast of what a future observation will be. Predicting often involves interpolating and extrapolating.

Hypothesizing - the process of proposing a tentative explanation, based on observations or inferences, for the occurrence of a set of observations or events. Hypotheses must be testable in order to be valid.

Controlling Variables - the process of deciding which variables or factors will influence the outcome of an experiment, situation, or event. In an experimental situation, the variables of interest are free to vary in response to variables over which the experimenter exercises control. Controlled variables are allowed to take on specific values.

Processing Data - the process of organizing rough data in a more compact and meaningful way (through ordering, rearranging, comparing), depicting the data pictorially or graphically, and processing data mathematically (finding slopes, tangents, etc.) to facilitate interpretations.

The following example requires students to make a prediction by applying underlying principles to a hypothetical situation.

Question 7:

A red blood cell placed in a concentrated salt solution will

Student Responses

20.9%	A.	take in water by osmosis, swell, and eventually burst
7.4%	B.	take in water by diffusion, swell, and eventually burst
59.2%	*C.	lose water by osmosis, shrink, and eventually die
12.5%	D.	lose water by diffusion, shrink, and eventually die
0.0%		no response

Written-Response Questions

On the written-response portion of the examination, students were expected to communicate their answers clearly and show all steps in their solution. All eight written-response questions were designed to evaluate at the taxonomic levels of application, understanding, and higher mental activities.

Each written-response question from the examination is given on the following pages with an appropriate answer. The total marks possible for each question is given, along with the average number of marks awarded. The distribution of marks awarded to students for each written-response question is shown in Table 7, Chapter 3.

Question 1 deals with cellular processes fundamental to life. Students must be able to apply principles regarding enzymatic action to the identification of the end products of this action.

> In a biological experiment, a piece of chewed unsweetened cracker is placed in a test-tube and incubated at body temperature for five minutes. At the conclusion of this period, Fehling's or Benedict's solution is added and the contents are heated. State ONE observation and ONE conclusion that could be made concerning the experiment.

Key: Observation: A color change occurs upon heating - the solution turns red (green, yellow, brick orange).

Conclusion: A reducing agent (a sugar) is present in a piece of chewed cracker. The cracker originally contained starch. The ptyalin (amylase) in saliva digests starch into sugar. Presence of sugar is detected by the Fehling or Benedict solution.

It was possible to score 3 marks for this question. The average number of marks awarded students was 0.97.

In question 2 students must recall knowledge of photosynthesis and respiration, then they must be able to list the differences between the two biochemical reactions.

List THREE differences between photosynthesis and respiration as biochemical reactions.

Key: The reactants as well as the end products are different in each process. Respiration is an energy-yielding process while photosynthesis is an energy-requiring process. In addition, photosynthesis requires sunlight to react with chlorophyll, which is present only in green plants. However, neither plants nor animals require sunlight or chlorophyll for respiration.

It was possible to score 3 marks for this question. The average number of marks awarded students was 1.6.

In question 3a, students must demonstrate an understanding of diabetes mellitus by applying the principles to the given information. In question 3b, students are required to formulate a procedure that could be used to control diabetes mellitus.

Diabetes mellitus (sugar diabetes) is characterized by the following symptoms:

I increased daily urine output
II thirst
III lack of energy

a. Explain the causes of the symptoms as they relate to diabetes mellitus.

Key: Diabetes mellitus is caused by an insufficient secretion of the hormone insulin. Insulin regulates the absorption of blood sugar by the body cells and thereby helps maintain a constant blood sugar. Should insulin levels fall, less blood sugar would be absorbed by the body cells and therefore the blood would become more hypertonic. The lack of energy can be associated with the glucose remaining in the blood and not entering the body cells, which would oxidize it to produce energy. The thirst and increased urine output can be associated with the excess blood sugar that is filtered into the nephron. Since only a portion of that sugar can be reabsorbed, the remaining glucose will pull water into the nephron by osmosis, thereby increasing urine output and thirst.

b. Explain ONE procedure used to control this disease.

Key: Since diabetes is characterized by an excess of sugar in the blood, one procedure to control the disease would be very strict regulation of the intake of carbohydrates (diet). The second procedure would be the daily injection of the hormone insulin, which would return the sugar level of the blood to normal.

It was possible to score 3 marks for this question. The average number of marks awarded students was 1.4.

In question 4 students are required to demonstrate comprehension of osmosis and diffusion by applying the associated principle to a particular situation.

a. During an allergic reaction, histamines are released into the blood causing capillaries to become permeable to plasma proteins. Explain why tissue swelling accompanies such a reaction.

Key: The plasma proteins that have left the capillaries will make the EFC isotonic with the blood (or decrease the osmotic force that draws H_2O back into the capillaries). Consequently, less H_2O will move into the blood, causing an accumulation of fluid or a swelling of tissues.

b. Explain why an injection of an antihistamine may help to reduce this swelling.

Key: Antihistamine ties up the active site of histamine and inactivates it (competitive inhibitor), thereby making the capillary impermeable to proteins.

It was possible to score 3 marks for this question. The average number of marks awarded to students was 1.0.

Question 5 requires students to analyse and interpret the given data, then make a prediction based on this analysis.

In an experiment that tested the effect on enzymes of food substances, students noted the following:

	Observation
boiled egg-white + HCl	no reaction
boiled egg-white + HCl + pepsin	digested egg-white
boiled egg-white + HCl + pepsin + unknown (x)	no reaction

	Observation
meat + HCl	no reaction
meat + HCl + pepsin	digested meat
meat + HCl + pepsin + unknown (x)	no reaction

Note: Unknown (x) does not change the pH.

From the experimental results above, predict the effect of unknown (x) on pepsin.

Key: Pepsin is an enzyme that digests protein. Unknown (x) is a competitive inhibitor that ties up the active site on the pepsin enzyme, thereby inactivating the enzyme.

It was possible to score 2 marks for this question. The average number of marks awarded to students was 1.2.

In question 6 students are required to demonstrate their understanding of chemical transmission between neurons by applying those concepts to a particular situation.

Some insecticides inhibit the action of the enzyme acetylcholinesterase (cholinesterase). Explain how such insecticides would kill insects.

Key: The proper operation of the synapse requires that the transmitter substance be removed from the synaptic gap as soon as it has done its job. The removal of acetycholine is accomplished by the enzyme acetylochinesterase. If removal does not take place, the proper functioning of neurons is inhibited and muscles cannot function properly.

It was possible to score 2 marks for this question. The average number of marks awarded to students was 0.47.

In question 7, students can demonstrate their comprehension of the subject matter covered by applying their knowledge of the neural anatomical structure and the transmission of nerve impulses.

> If an axon is sufficiently stimulated some distance from its end, an impulse travels in both directions from the site of stimulation. Explain why impulses travel in ONE direction only in neural circuits.

Key: The axon end has the ability to manufacture and release transmitter substances, but the dendrite end does not, hence the impulse can only travel from axon end across the synaptic gap to the associated dendrite end.

There were 2 marks possible for this question. The average number of marks awarded to students was 0.46.

Question 8 requires students to analyse a situation and apply the principles learned concerning the kidneys as a homeostatic mechanism, and then make a prediction.

> A sailor lost at sea drinks sea water as a means of replenishing the body fluids lost through sweating and breathing. (Body tissues are 4% salt, while the sea has a 7% salt concentration.) State in physiological terms whether drinking sea water will help the sailor.

Key: The drinking of salt water will cause the sailor to dehydrate. The nephron is able to reabsorb only a 4% salt concentration by active transport, which leaves a 3% salt solution in the nephron. The remaining 3% salt solution in the nephron opposes the osmotic force of the surrounding extracellular fluid. Thus water is lost when this excess salt is excreted.

It was possible to score 2 marks for this question. The average number of marks awarded to students was 0.77.

CHAPTER 3

Results

Validity and Reliability

The content validity of the examination was established by the procedure for examination development outlined in Chapter 2. Each question was mapped to a specific topic statement defining some aspect of the curriculum. The Examination Review Committee evaluated each question, and the examination as a whole, for content validity.

The KR-20 coefficient for the multiple-choice portion of the examination was 0.89, and Cronbach's alpha for the total test was 0.91. These values are very satisfactory for an achievement test measuring a broad range of concepts and skills.

The inter-marker reliability for the marking of the written-response questions was also examined. The marking key for each question was prepared by the Student Evaluation Branch and then revised following discussion with four head markers. During the orientation session, teachers marked three common student responses for each question and discussed the awarding of marks. All teachers then marked an additional three student responses for each question so that the consistency of the marking procedures could be checked. At the beginning of each morning and afternoon marking session, all teachers marked two common student responses for each question. Any discrepancies were again discussed. For questions on those papers marked by all teachers, 78.3% of the marks awarded were in agreement, 21.1% deviated from the consensus mark by one mark, and 0.6% deviated by more than one mark. During the marking, one teacher marked questions 1 to 4, and a different teacher marked questions 5 to 8 for each paper.

Provincial Averages

The classification of examination questions according to subject matter topic and taxonomic level has been presented in Table 1, Chapter 2. Subtest scores were computed for each of the eight subject matter topics, for the three taxonomic levels, and for the questions requiring the application of scientific process skills. Table 2 contains the provincial averages for these subtests and for the total examination. In each case, an average is given for the written-response questions, the multiple-choice questions, and the combination of the two (total). Averages are based on raw scores, which are the number of marks obtained on each subtest. The total marks possible is identified for the written-response and multiple-choice components of each subtest. For the multiple-choice component of each subtest, the average in per cent is also given.

Averages are based on 5558 students. Differences between total averages and component averages are due to rounding.

Table 2

Provincial Averages for Subtests

Subtest	Total Marks Possible		Raw Score Averages		
	Written-Response	Multiple-Choice	Written-Response	Multiple-Choice	Total
Topics					
Physical Properties of Cells	3	11*	0.97	6.8 (61.8%)	7.8
Nutrition	5	14	2.7	7.1 (50.7%)	9.9
Circulation	3	10	1.0	5.4 (54.0%)	6.4
Gas Exchange	0	7	--	5.1 (72.8%)	5.1
Cellular Respiration	0	8	--	5.3 (66.2%)	5.3
Excretion	2	5	0.77	3.2 (64.0%)	4.0
Metabolic Controls	7	16*	2.4	9.9 (61.8%)	12.2
Human Reproduction	0	7	--	4.1 (58.5%)	4.1
Process Skills	15	20	5.8	11.3 (56.5%)	17.1
Cognitive Levels					
Knowledge	3	28	1.6	16.5 (58.9%)	18.1
Application and Understanding	13	39	4.3	23.5 (60.2%)	27.9
Higher Mental Activities	4	11	1.9	6.9 (62.7%)	8.8
TOTAL EXAMINATION	20	78	7.8	47.0 (60.3%)	54.8

*Questions 6 and 65 were omitted from the analysis.

The standard deviation for the total examination was 14.8 raw score points.

The multiple-choice averages in per cent provide an indication of how well students performed within subject matter topics and taxonomic levels. The average for the multiple-choice questions on gas exchange is considerably higher than the overall average for the multiple-choice questions. The average for the multiple-choice questions on nutrition is considerably lower than the overall average for the multiple-choice questions.

It is not meaningful to compare total subtest scores or written-response subtest scores across topics or taxonomic levels because of the uneven distribution of written-response questions. However, jurisdictions and schools can compare their averages to the provincial averages to help identify strengths and weaknesses in their programs.

Comparison of Multiple-Choice and Written-Response Questions

The average mark attained on all multiple-choice questions was 60.3%, and the average on all written-response questions was 39.0%. It is not readily apparent why the written-response questions were answered so poorly.

In comparing written-response and multiple-choice items based on the same curricular concepts, there is little similarity in terms of item difficulty. In nearly every case the difficulty level of the written-response questions is lower than those of the corresponding multiple-choice questions. In most cases, the difference is considerable. This would appear to imply that the students' difficulty with the written-response portion of the exam lies not in a general lack of comprehension of the concepts involved, but rather in the nature of the format of the required response.

In written-response question 1, students must be able to apply principles regarding enzymatic action to the identification of the end products of this action. The difficulty level for this question is 0.32. The difficulty levels of multiple-choice questions using a similar concept are:

Q. 5 - 0.70
Q. 19 - 0.46
Q. 20 - 0.66
Q. 27 - 0.65
Q. 28 - 0.77
Q. 23 - 0.56
Q. 24 - 0.34

In written-response question 2, students must recall knowledge of photosynthesis and respiration, then must be able to list the differences between the two biochemical reactions. The difficulty level for this question is 0.53. The difficulty levels of multiple-choice questions using a similar concept are:

Q. 15 - 0.28
Q. 16 - 0.52
Q. 17 - 0.30
Q. 18 - 0.84

In written-response question 3a, students must demonstrate understanding of diabetes mellitus by applying the principle to the given information. In question 3b, students are required to formulate a procedure that could be used to control diabetes mellitus. The difficulty level for this question is 0.47. The difficulty levels of multiple-choice questions using a similar concept are:

Q. 57 - 0.55
Q. 58 - 0.67
Q. 63 - 0.68
Q. 64 - 0.86
Q. 66 - 0.53
Q. 67 - 0.67

In written-response question 4, students are required to demonstrate comprehension of osmosis and diffusion by applying the associated principle to a particular situation. The difficulty level for this question is 0.33. The difficulty levels of multiple-choice questions using a similar concept are:

Q. 25 - 0.75
Q. 26 - 0.57
Q. 29 - 0.48
Q. 30 - 0.81
Q. 31 - 0.45
Q. 33 - 0.44
Q. 34 - 0.34
Q. 35 - 0.47
Q. 53 - 0.49

Written-response question 5 requires students to analyse and interpret the given data, then make a prediction based on this analysis. The difficulty level for this question is 0.60. The difficulty levels of multiple-choice questions using a similar concept are:

Q. 10 - 0.73
Q. 11 - 0.69
Q. 21 - 0.61
Q. 23 - 0.56
Q. 27 - 0.65

In written-response question 6, students can demonstrate their understanding of chemical transmission between neurons by applying those concepts to a particular situation. The difficulty level for this question is 0.24. The difficulty levels of multiple-choice questions using a similar concept are:

Q. 47 - 0.86
Q. 51 - 0.48
Q. 70 - 0.83
Q. 71 - 0.55

Students can demonstrate their comprehension of the subject matter covered in written-response question 7 by applying their knowledge of the neural anatomical structure and the transmission of nerve impulses. The difficulty level for this question is 0.23. The difficulty levels of multiple-choice questions using a similar concept are:

Q. 69 - 0.57
Q. 70 - 0.83
Q. 71 - 0.55

Written-response question 8 requires students to analyse a situation and apply the principles learned concerning the kidneys as a homeostatic mechanism, and then make a prediction. The difficulty level for this question is 0.39. The difficulty levels of multiple-choice questions using a similar concept are:

Q. 52 - 0.74
Q. 53 - 0.49
Q. 54 - 0.77
Q. 55 - 0.72
Q. 56 - 0.46

Standard-Setting

Every effort was made to design a Biology 30 diploma examination that would be a valid and reliable measure of what students can be expected to know as a result of instruction in this course. A specific standard or level of expectation inherent in the examination was established through careful test development procedures. To ensure that each form of the examination administered in 1984 will be parallel to each other, the Student Evaluation Branch has adopted a process of standard-setting. One way to review the standards inherent in each examination is to involve classroom teachers in making judgments about the difficulty of the examination.

The teachers who marked the written-response portion of the examination reviewed the difficulty level of each question in terms of a borderline passing student (who merits 50%), a borderline "B" student (who merits 65%), and a borderline "A" student (who merits 80%). After teachers gave their initial judgments on question difficulty, they were given information about the actual distribution of students' examination marks. They were then given the opportunity to modify their judgments. Judgments from all teachers for all examination questions were pooled to determine the examination scores that teachers felt should be set equivalent to 50%, 65%, and 80%. For the January 1984 diploma examination, teachers felt that 43% should be raised to 50%, that 60% should be raised to 65%, and that 76% should be raised to 80%. These cut-off scores are based on the judgments of 48, 24, and 24 teachers respectively.

Transformation of Examination Marks

The final decision on the transformation to be applied to the examination scores was based on an analysis of the data from the teacher judgments, the distribution of examination marks, the distribution of school marks, and the distribution of marks in previous years. The examination marks were adjusted according to the transformation presented in Table 3.

Table 3

Transformation of Examination Marks

Actual Examination Marks (%)	Adjusted Examination Marks (%)
0 - 43	0 - 47
44 - 60	50 - 64
61 - 76	65 - 79
77 - 100	80 - 100

Scores between the two end points of each range were converted according to linear transformation. Additional adjustments were made to the examination marks so that students would not receive final blended marks of 48% or 49%.

The overall effect of the transformation was to raise the average from 55.9% to 60.0%.

Relationship Between Examination Mark and School Mark

The provincial averages and standard deviations for the school-awarded mark, the transformed examination mark, and the final blended mark are presented in Table 4.

Table 4

Summary Statistics for School Mark, Examination Mark, and Final Mark

	School-Awarded Mark	Examination Mark	Final Blended Mark
Average	65.7%	60.0%	63.2%
Standard Deviation	12.5%	14.5%	12.6%

The average school mark is 5.7% higher than the average examination mark after transformation. The correlation between school mark and examination mark was 0.74, which indicates a fairly close agreement in the rank ordering of the students based on the two sets of marks.

The percentages of students receiving A's, B's, C's, and F's are presented in Table 5 for the school mark, the examination mark, and the final blended mark.

Table 5

Percentages of Students Receiving A's, B's, C's, and F's

Score	School-Awarded Mark	Examination Mark	Final Blended Mark
A(80-100%)	16.4	10.8	12.0
B(65-79%)	36.6	26.4	32.4
C(50-64%)	39.4	39.9	45.1
F(0-49%)	7.5	22.8	10.5

Results for Individual Questions

Multiple-Choice Questions

The percentage of students choosing each response for each multiple-choice question (item) is given in Table 6. The correct response (key) for each question is also identified.

Table 6

Results for Individual Multiple-Choice Questions

ITEM	KEY	Distribution of Responses in %*				ITEM	KEY	Distribution of Responses in %*			
		A	B	C	D			A	B	C	D
1	C	35.3	8.1	46.3	10.0	41	D	0.8	1.7	17.0	80.5
2	D	13.2	5.9	7.8	73.0	42	B	4.4	82.3	5.7	7.6
3	A	67.0	10.3	19.5	3.1	43	B	17.9	76.1	1.2	4.7
4	C	35.8	30.6	32.7	0.7	44	A	74.8	8.3	10.2	6.7
5	B	15.9	69.7	8.3	6.0	45	C	2.8	6.7	80.0	10.5
6	**					46	D	11.5	13.0	5.8	69.6
7	C	20.9	7.4	59.2	12.5	47	C	5.3	6.3	86.1	2.4
8	B	31.3	54.5	0.8	13.4	48	C	14.1	14.0	66.9	5.1
9	B	7.4	80.3	9.2	3.0	49	D	9.0	6.2	22.1	62.6
10	C	5.8	9.2	72.8	12.1	50	A	45.6	33.5	8.5	12.3
11	B	5.5	68.9	22.0	3.6	51	A	48.4	16.4	26.3	8.9
12	B	1.3	55.7	38.2	4.7	52	A	73.5	10.3	9.7	6.4
13	C	23.1	16.5	39.1	21.1	53	C	14.6	27.3	49.3	8.8
14	A	38.6	17.3	26.4	17.6	54	D	9.0	5.0	8.7	77.3
15	C	18.9	20.5	27.8	32.7	55	C	10.2	11.0	71.7	7.1
16	B	24.2	51.5	14.1	10.1	56	A	46.4	14.1	27.6	11.8
17	B	5.6	30.1	28.5	35.7	57	B	27.5	54.5	8.6	9.4
18	D	8.0	2.5	5.8	83.7	58	B	4.1	67.3	27.3	1.2
19	B	4.6	45.2	37.7	12.5	59	B	7.1	36.6	38.0	18.2
20	A	66.0	8.8	6.6	18.6	60	C	25.3	18.8	40.7	15.2
21	C	***	17.2	61.4	21.4	61	B	13.4	78.7	3.3	4.7
22	B	17.2	38.0	26.1	18.5	62	C	27.9	2.4	52.0	17.7
23	B	14.0	55.9	6.4	23.7	63	B	10.6	67.7	8.3	13.3
24	C	27.9	12.0	34.2	25.8	64	C	6.3	1.3	85.8	6.5
25	D	4.5	4.6	16.0	74.8	65	**				
26	B	16.6	57.2	14.6	11.6	66	C	20.0	11.2	52.8	15.9
27	C	24.7	5.4	64.8	5.0	67	D	6.1	12.2	14.4	67.2
28	B	4.9	77.2	13.0	4.9	68	A	76.3	7.0	13.9	2.7
29	B	11.4	47.8	29.7	11.0	69	D	12.6	17.6	12.9	56.8
30	C	6.2	6.7	81.0	6.0	70	D	3.9	4.1	9.5	82.5
31	A	45.4	23.9	24.4	6.3	71	C	6.7	23.9	54.9	14.4
32	A	52.5	9.9	17.0	20.6	72	C	13.4	12.6	59.8	14.1
33	A	44.0	22.8	9.4	23.8	73	C	13.9	22.3	53.7	9.9
34	C	9.3	49.5	34.4	6.8	74	A	58.5	5.5	24.6	11.3
35	C	22.1	19.3	47.1	11.4	75	B	3.9	91.2	1.2	3.7
36	A	52.6	28.7	7.1	11.5	76	B	13.0	64.3	7.2	15.4
37	B	15.3	61.5	18.6	4.5	77	D	32.0	7.9	4.9	55.1
38	A	72.6	4.2	3.5	19.6	78	B	25.7	41.9	23.5	8.9
39	A	66.9	20.3	7.5	5.1	79	C	4.0	14.4	72.2	9.2
40	B	19.2	73.2	2.9	4.7	80	C	32.0	12.9	29.1	25.9

*The sum of the percentages for some questions is less than 100% because the No Response category is not included. This category is less than 0.4% for all questions.

**Questions 6 and 65 were omitted from the analysis.

***Question 21 was double-keyed to A and C.

Written-Response Questions

The percentage of students awarded each mark for each question is given in Table 7.

Table 7

Distribution of Marks for Written-Response Questions

Question Number	Percentage of Students Obtaining Each Mark				
	NR*	0	1	2	3
1	5.7	39.4	24.6	18.2	12.1
2	4.7	12.0	30.2	33.4	19.7
3	1.2	10.1	46.8	29.7	12.1
4	4.7	26.8	43.5	17.6	7.4
5	4.6	18.3	37.9	39.3	
6	12.8	56.7	14.4	16.1	
7	14.2	54.1	17.5	14.2	
8	1.5	28.6	62.8	7.3	

The total number of marks possible, the average mark awarded to students, and the difficulty level for each written-response question are summarized in Table 8. The difficulty level is the average divided by total marks possible.

Table 8

Average Marks Awarded for Written-Response Questions

Question Number	Total Mark	Average Mark	Difficulty Level
1	3	0.97	0.32
2	3	1.6	0.53
3	3	1.4	0.47
4	3	1.0	0.33
5	2	1.2	0.60
6	2	0.47	0.24
7	2	0.46	0.23
8	2	0.77	0.39

POOR

QUALITY

ORIGINAL